GPWS

U.S. Navy/Marine Corps
CH-53D/E, MH-53E, and CH-46E
AN/AYQ-23(V)1
Ground Proximity Warning System (GPWS)

PMA209GPWS@navy.mil

GPWS Organization

GPWS

Production Systems Team Leader

Systems Engineering

Logistics

T&E

H-53

- *Platform Liaison*
- *PMA-261*
- *NADEP Cherry Pt*

H-46

- *Platform Liaison*
- *PMA-226 Cherry Pt*

CFIT

GPWS

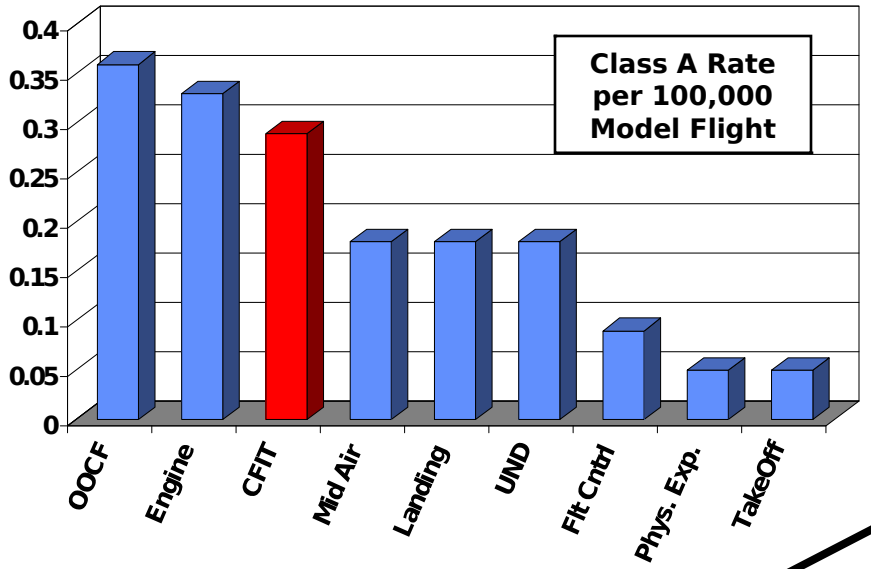
PMA-209

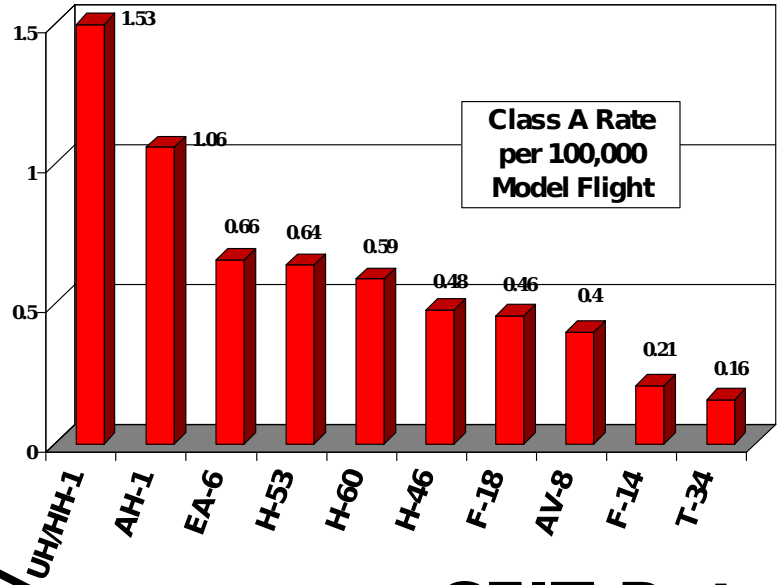
CFIT -Controlled Flight Into Terrain

- Occurs With A Perfectly Functioning Aircraft
- Capable Crew; No One Incapacitated
- No System Failures

Why GPWS?

GPWS



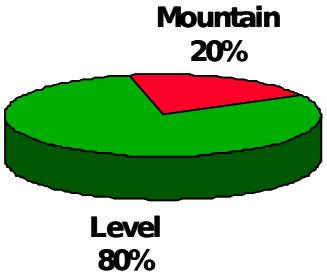


FY90 – FY00 Class A Mishaps

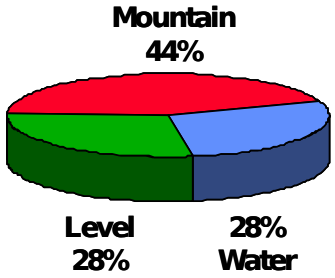
CFIT Rate By Platform FY90-FY00

CFIT Analysis By Terrain Type

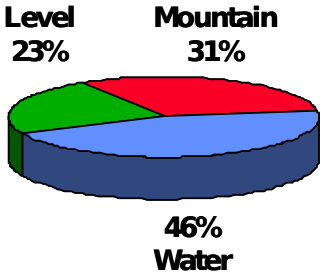
TRANSPORT, AEW, & PATROL



TACTICAL



HELICOPTER



What is GPWS?

GPWS - *A SAFETY BACK-UP SYSTEM* that processes real-time aircraft sensor data, and provides the crew with timely and accurate warnings of an impending controlled flight into terrain (CFIT).

What GPWS is not!

GPWS is not LAWS. Per PMA-226 direction, the old LAWS tone generators were removed and the LAWS aural annunciation, controlled by the APN-171, now utilizes a spare voice annunciation in the GPWC.

GPWS is also NOT a performance aid. It is not meant to allow the crew to fly the aircraft in a purposely, overly aggressive manner until the GPWS issues a warning.

GPWS vs Non-GPWS Functions

GPWS Function - Altitude loss after takeoff; predictive CFIT

NON-GPWS Function - “Blade Stall”, “Low Fuel”, “Altitude”

Altitude Annunciation of AN/APN-171 Bug Setting

PMA-209

GPWS

This alert is issued when the aircraft descends from above to below the low altitude settings selected on either the pilot and/or co-pilot radar altimeter height indicators. If the two indicators are set such that they activate two altitude calls in a 3 second period, the second altitude call is inhibited. This call is inhibited during takeoffs and landings for the CH/MH-53s. This alert is not inhibited for the CH-46E during landing and is available at all times the GPWC and the radar altimeter are operational.

"ALTITUDE" (Call issued once)

There is no visual cue other than light of RADALT Indicator

Call will not be issured again until aircraft climbs back above each index setting.

Aircraft Sensor Inputs to the GPWS Processor

- Radar altimeter - data and validity
- Pitch and roll - data
- Barometric altitude* - data and validity
- Barometric altitude rate* - data and validity
- Glide slope and Localizer - data and validity (CH/MH-53E)
- Engine torque
- Indicated Airspeed

* Either Barometric altitude or Barometric altitude rate may be used

Major WRA Descriptions

GPWS Computer (GPWC). The GPWC consists of the hardware and software that process flight data inputs and implement the GPWS algorithm. The GPWC issues warnings when unsafe flight conditions exist or when GPWS equipment and/or aircraft sensor failures are detected.

GPWC Mounting Base. The Mounting Base provides a secure mount for the GPWC. Connectors on the Mounting Base provide the GPWC aircraft power and instrument data. The Push-To-Test (PTT) switch on the base allows for Commanded Built-In-Test (BIT) of the GPWS System.

Miscellaneous Controls and Indicators.

1. The Caution Advisory Panel contains the GPWS INOP and ALERT lamps
   (CH-53D/E & MH-53E).
2. The Control Display Navigation Unit (CDNU) provides operational status and control of the GPWS in the CH-46E aircraft.

Physical Characteristics

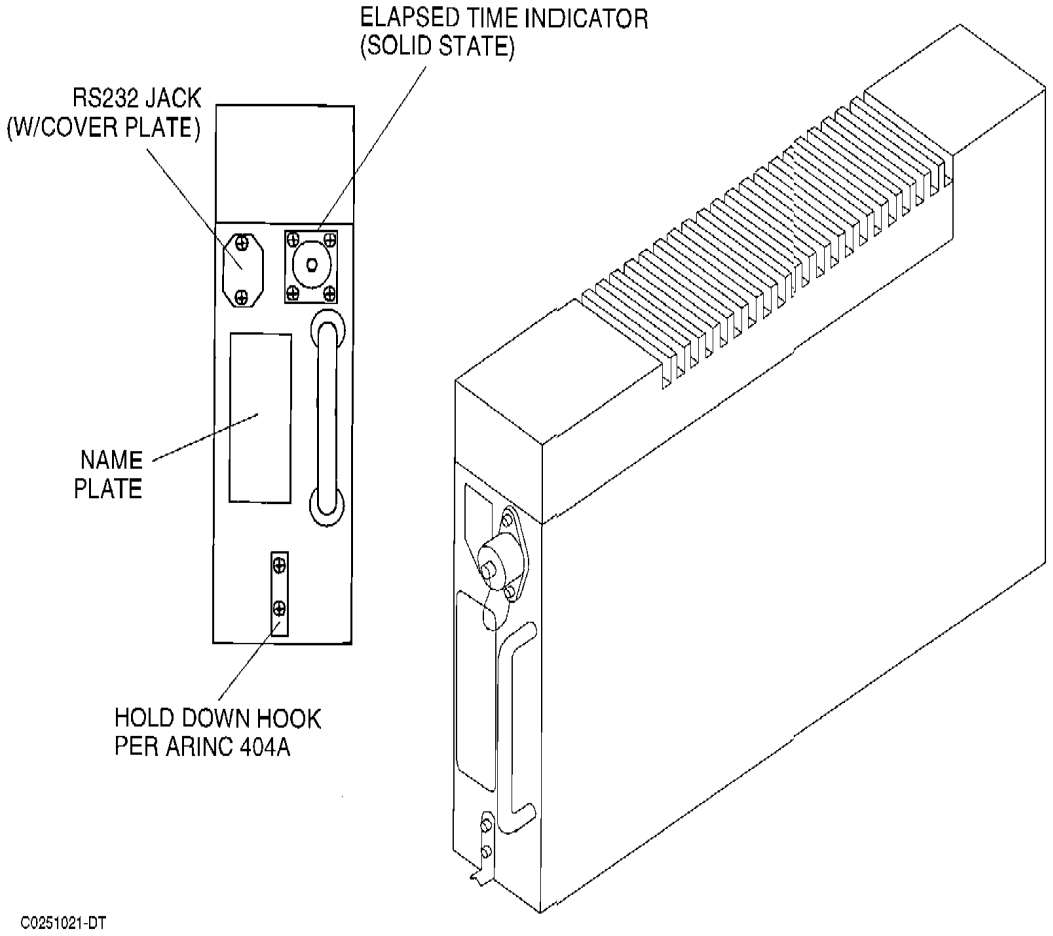
Physical Dimensions.

	Processor	Mount
Height:	7.62”	7.50”
Width:	2.25”	2.55”
Depth:	12.40”	19.25”
Weight:	7.0 lbs.14 oz.	2 lbs. 10 oz.

AC Electrical Power Inputs.

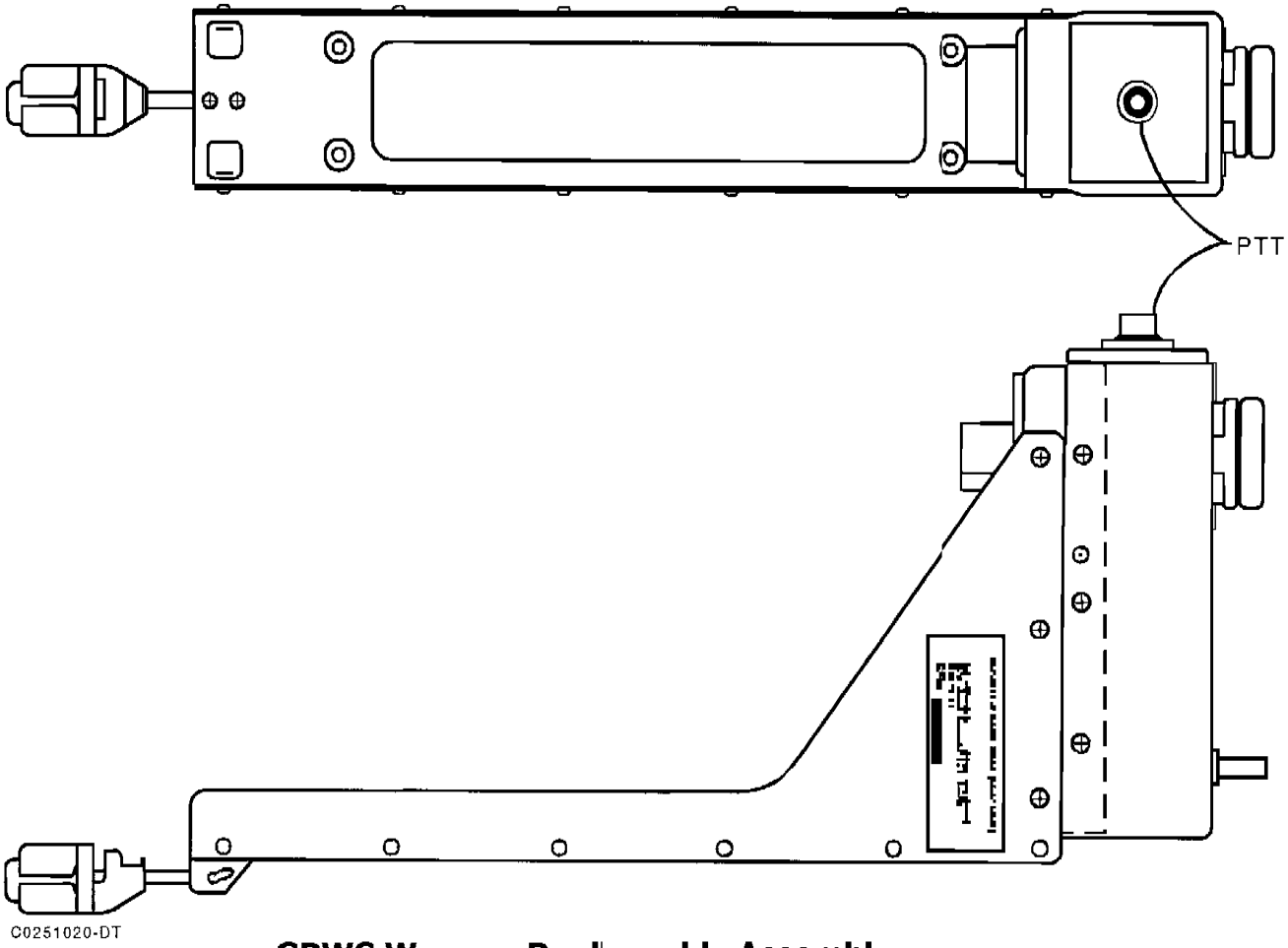
Nominal Input	Single Phase, 115 VAC, 400 Hz.
Power Dissipation	45 Watts Nominal
	70 Watts Absolute Maximum

Physical Characteristics (Cont'd)



GPWS Weapon Replaceable Assembly

Physical Characteristics (Cont'd)

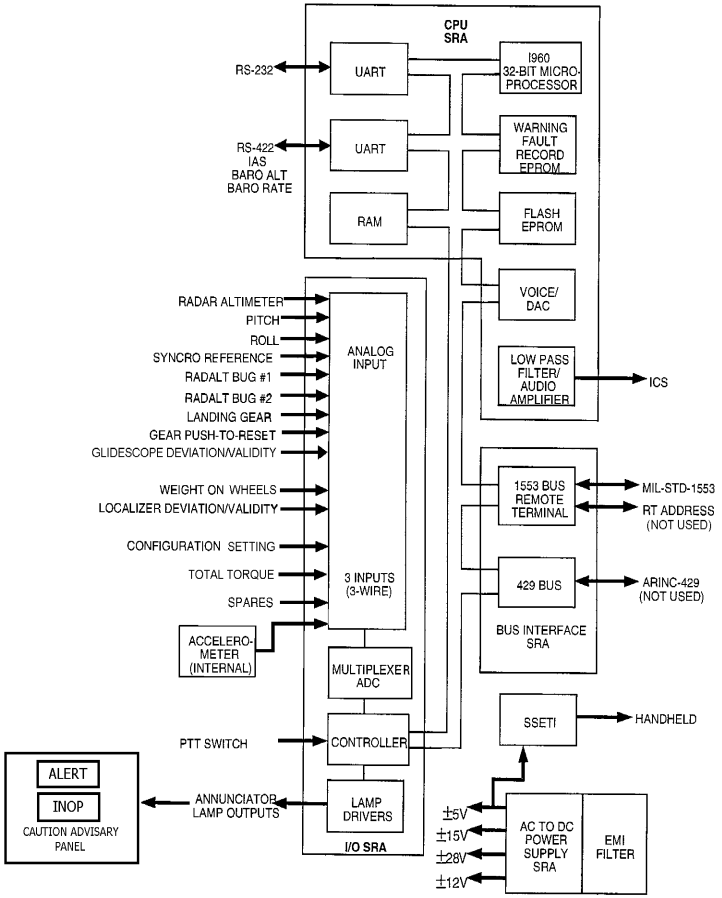


GPWS Weapon Replaceable Assembly

GPWS

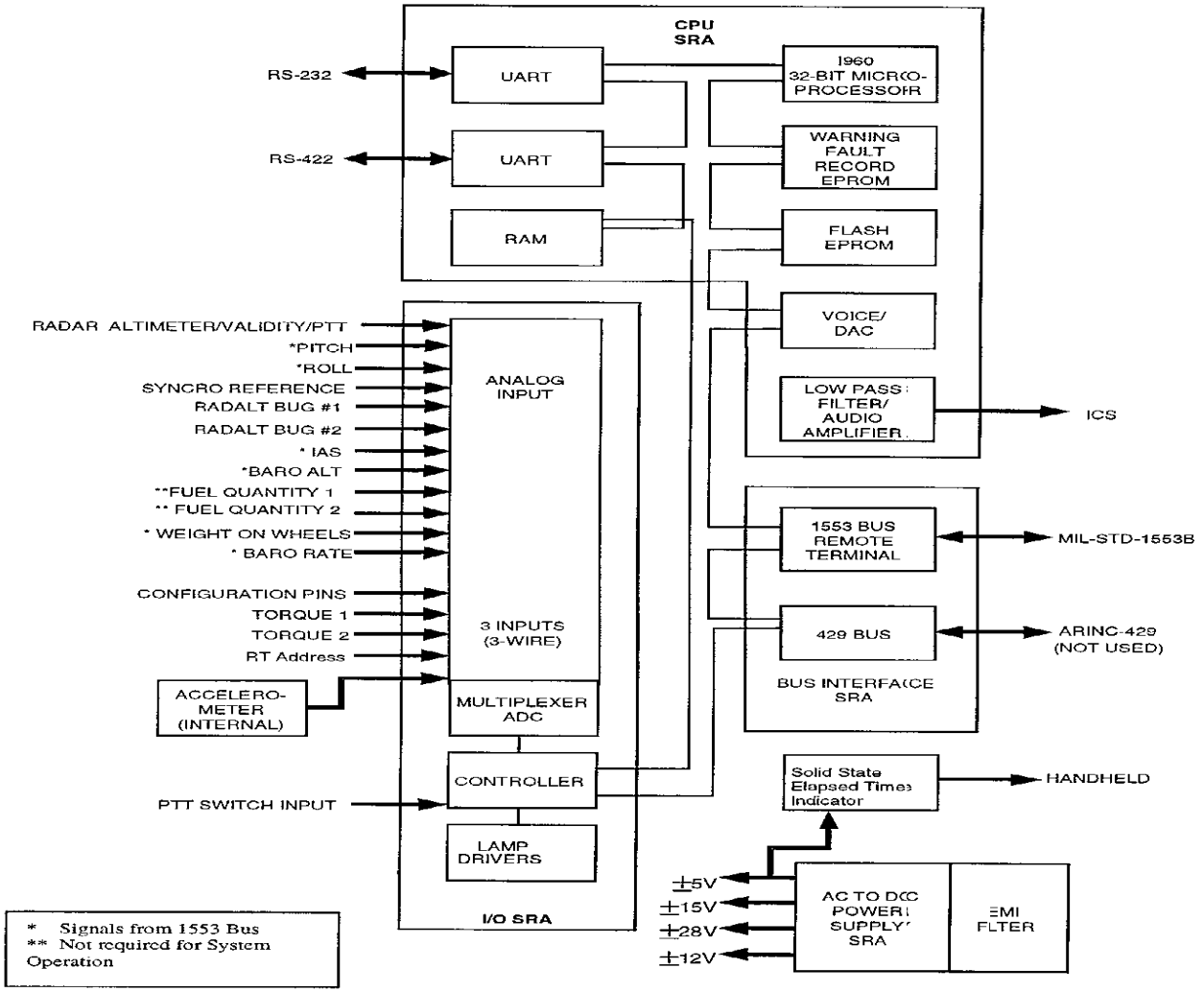
GPWS Integration Into The H-53 and H-46

H53 GPWS Simplified Block Diagram



H-53 GPWS Simplified Block Diagram

H46 GPWS Simplified Block Diagram



H-46 GPWS Simplified Block Diagram

Major GPWS WRA Locations

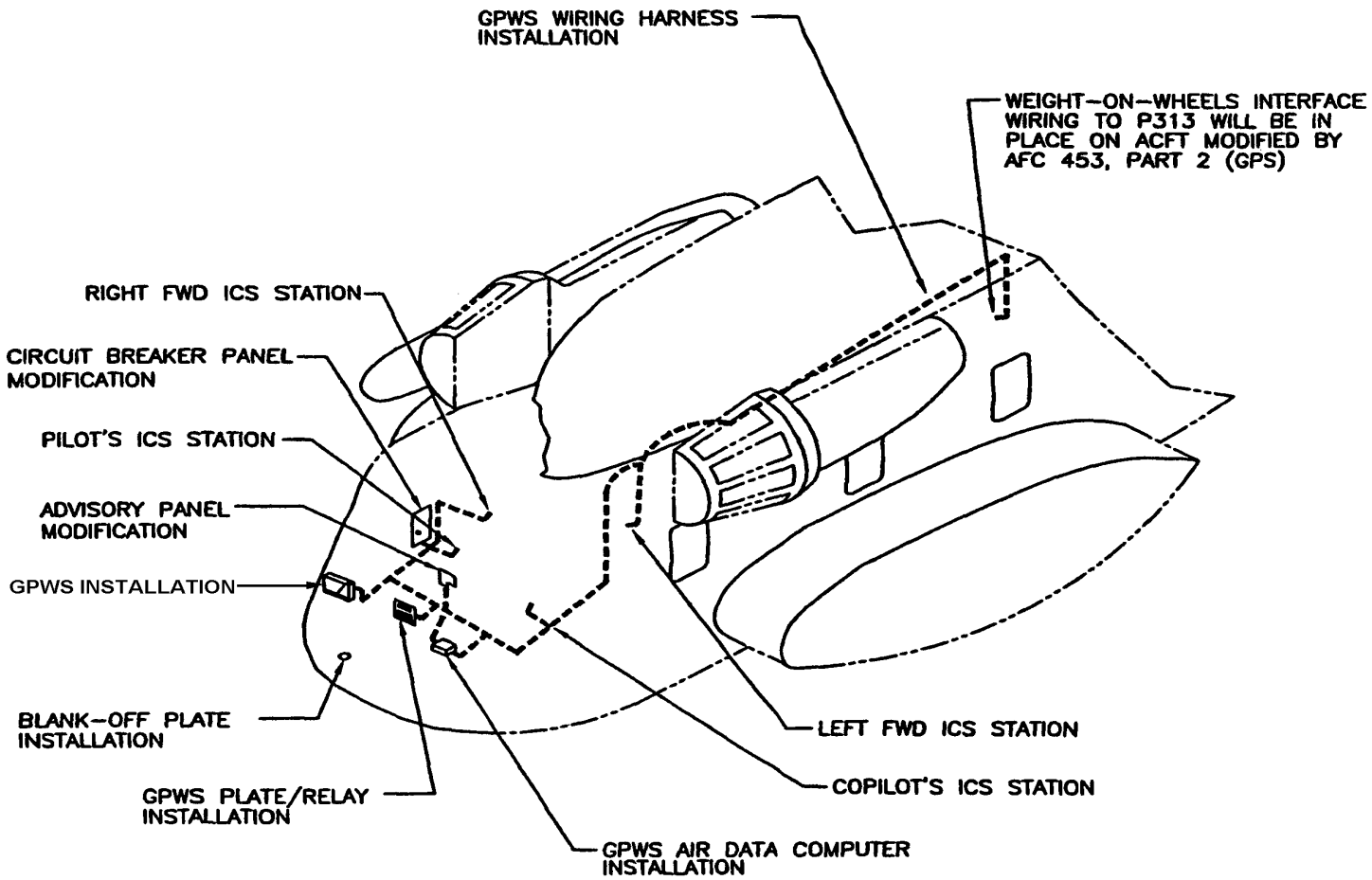
CH-53D - Lower right E-bay for GPWC and Mounting Base
Lower left E-bay for new ADC

CH-53E - On top of right hand circuit breaker panel for GPWC and Mounting Base Lower left E-bay for new ADC

MH-53E - Lower left E-bay for GPWC, Mounting Base and new ADC

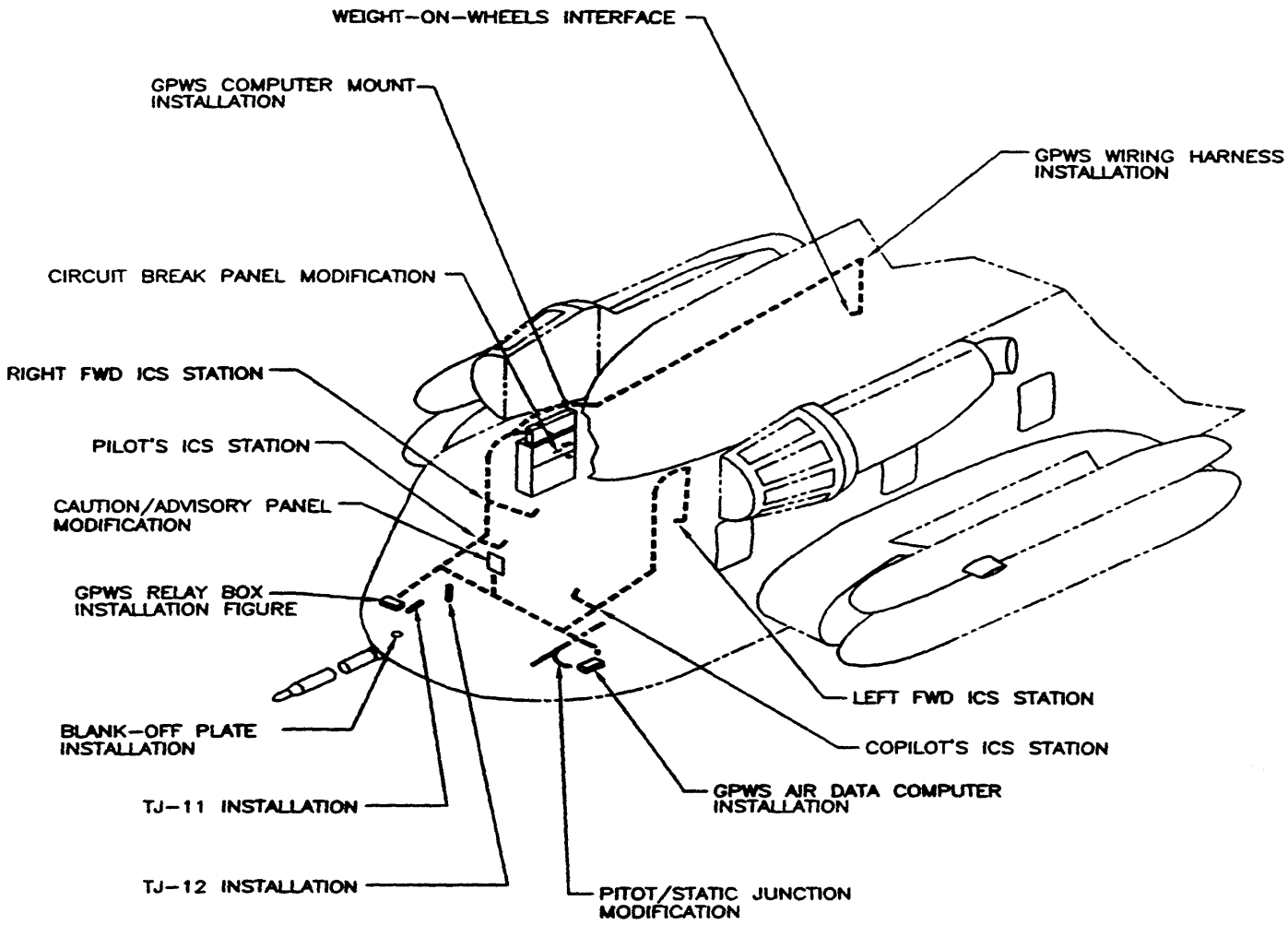
CH-46E - Nose E-bay for GPWC, Mounting Base and new ADC

CH-53D GPWS Location


GPWS WIRING HARNESS INSTALLATION
WEIGHT-ON-WHEELS INTERFACE WIRING TO P313 WILL BE IN PLACE ON ACFT MODIFIED BY AFC 453, PART 2 (GPS)
RIGHT FWD ICS STATION
CIRCUIT BREAKER PANEL MODIFICATION
PILOT'S ICS STATION
ADVISORY PANEL MODIFICATION
GPWS INSTALLATION
BLANK-OFF PLATE INSTALLATION
GPWS PLATE/RELAY INSTALLATION
GPWS AIR DATA COMPUTER INSTALLATION
LEFT FWD ICS STATION
COPILOT'S ICS STATION

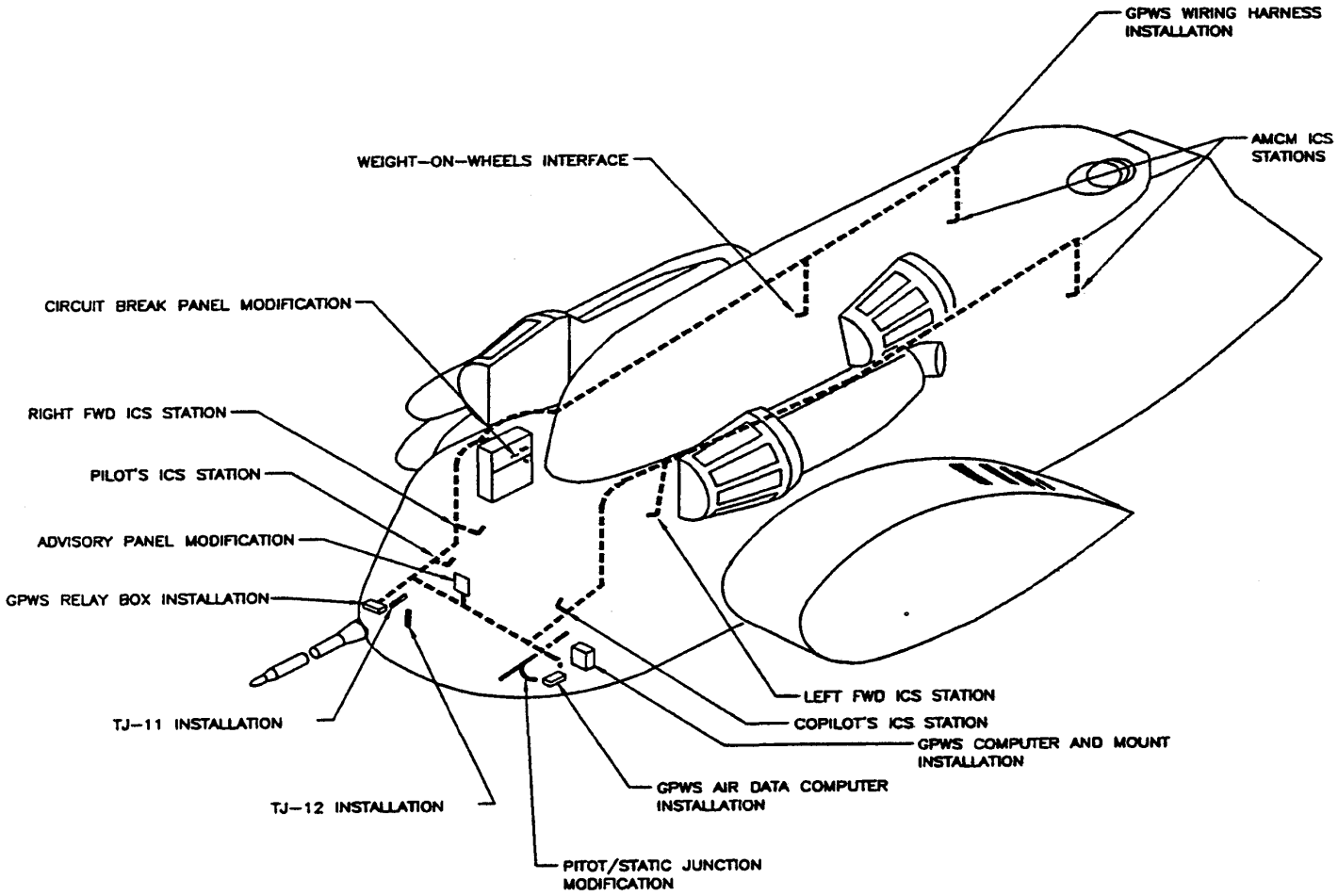
CH-53D GPWS Installation Location

CH-53E GPWS Location



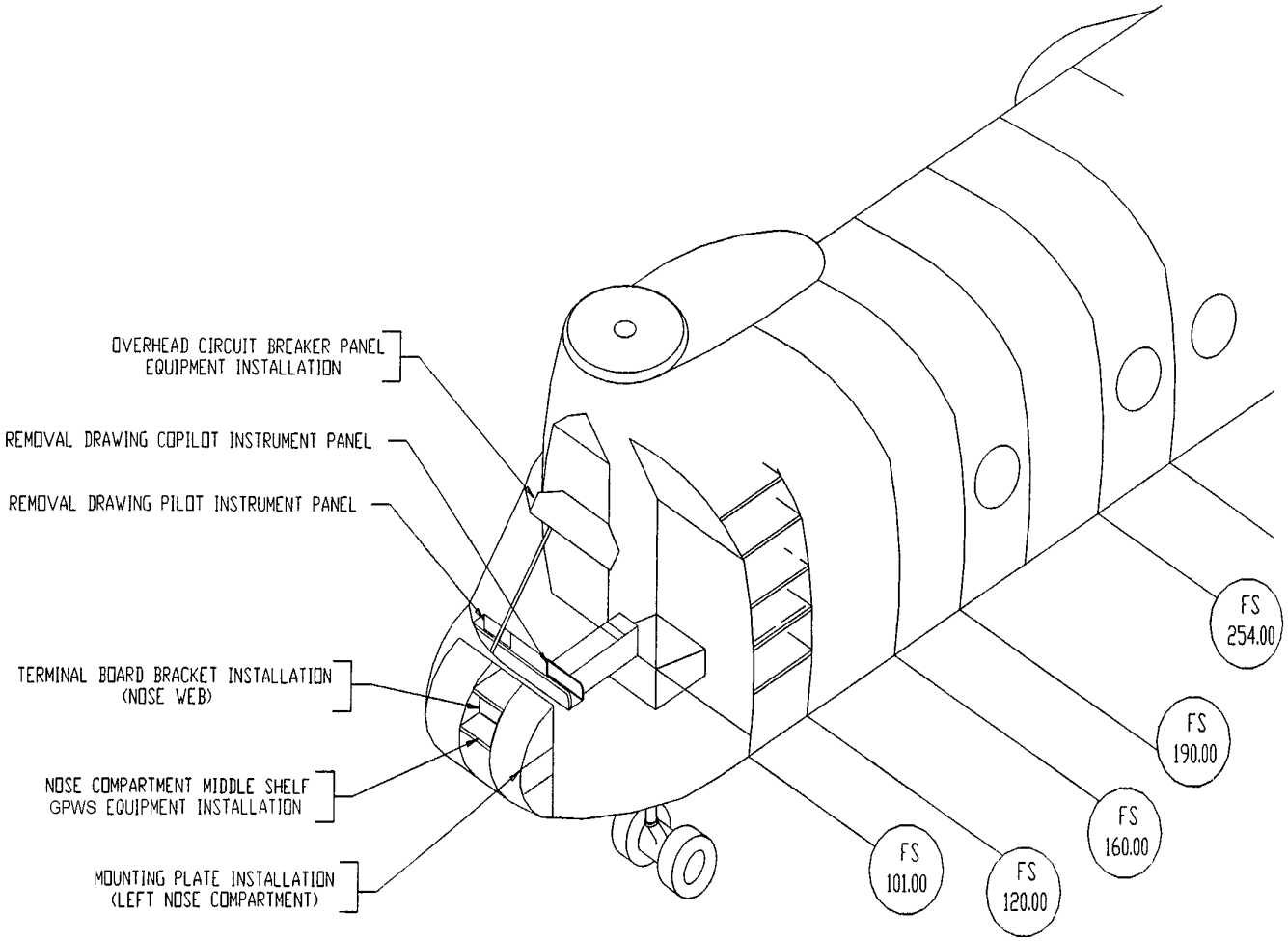
CH-53E GPWS Installation Location

MH-53E GPWS Location



MH-53E GPWS Installation Location

CH-46E GPWS Location



CH-46E GPWS Installation Location

GPWS

GPWS Warnings

When is the GPWS Active?

The GPWS provides warnings for CFIT prevention and unsafe flight conditions during the following phases of flight:

- Takeoff and Climb out
- Enroute cruise
- Descent, approach, hover, and landing

Protection is also provided when these phases of flight encompass a slung load, or low level maneuvers

Six Basic GPWS Warnings

GPWS

Condition	Warning	Frequency
Altitude Loss After Takeoff	Pull Up, Pull Up	Issued once
Impending CFIT	Whoop Whoop, Pull Up, Pull Up	Issued once
Drifting below glideslope (CH-53E/MH-53E Only)	Below Glideslope, Below Glideslope	Repeated at 3 sec intervals until condition is corrected
Excessive bank angle	Bank Angle, Bank Angle	Issued once
Trying to land with gear up CH-53D/CH-53E/MH-53E Only)	Gear, Gear	Repeated at 3 sec intervals until condition is corrected
Impending tail strike CH-53D/CH-53E/MH-53E Only)	Tail	Issued once

Prioritizing of Warnings

The purpose of prioritizing is to issue the most urgent warning first in the event conditions lead to two warnings being generated simultaneously. Also, when two or more warnings are needed, each warning will be completed in its entirety before the next warning is issued. This prevents garbling of the warnings such as “Whoop Whoop, Pull, Below, Tail”, a meaningless and confusing mixture of words.

Operational Characteristics Matrix

Operational Characteristics	CH-53D	CH-53E	MH-53E	CH-46E
Altitude Loss After Takeoff Warning	X	X	X	X
Predictive CFIT Warning	X	X	X	X
ILS Glide Slope Deviation Warning		X	X	
Excessive Bank Angle Warning	X	X	X	X
Non-Predictive, Selectable Altitude Callout	X	X	X	X
Landing Gear Warning	X	X	X	
Tail Strike Warning	X	X	X	

Processor Audio Outputs

The GPWS Voice Warning interface to the aircraft is via discrete wire connections to the aircraft's Inter-Communications System (ICS). The GPWS will track the ICS volume control setting and output aural warnings 3db higher than the volume set. The Low level audio output is interfaced to the following:

	PILOT	CO-PILOT	GUNNER	CREW CHIEF	AMCM STATIONS (2)
CH-53E	X	X	X	X	
MH-53E	X	X	X	X	X
CH-53D	X	X	X	X	
CH-46E	X	X	X	X	X

Aural Advisories

The GPWS issues aural advisories that are not warnings. These occur during the initial power up and when built-in-test results are expressed or accessed.

At power-up, with a normally operating GPWS, one hears, “Whoop Whoop, Pull Up, Pull Up . . . Bank Angle, Bank Angle . . . GPWS Ready”. This is to give the crew familiarity with the tone and volume of a typical set of warnings without startling them.

Other advisories are issued when IBIT and CBIT are active and detect a fault and when fault histories are requested. These will be covered in the section on Built-In-Test.

PMA-209

GPWS

Warning Characteristics

Altitude Loss After Takeoff

GPWS

This warning is issued to prevent a CFIT shortly after takeoff and during the initial climb out. This warning protects against altitude loss due to in-air descent, rising terrain, or a combination of the two.

Aircraft's AGL Altitude	Warning Altitude
40 - 50 feet AGL	20 feet AGL
51 - 80 feet AGL	Aircraft Altitude AGL minus 30 feet
81 - 250 feet AGL	50 feet AGL

This protective mode is active for 60 seconds after takeoff or up to an altitude of 250 feet AGL, whichever comes first. After that, the predictive impending CFIT warning takes over.

Aural warning ***"PULL UP PULL UP"***

Warning issued once.

Visual warning ***GPWS ALERT lamp on the Caution Advisory Panel illuminates and stays lit for the CH/MH-53 series aircraft. There is no indication for the CH-46E aircraft .***

Re-arm Condition ***Aircraft climbs to 80 feet AGL. The ALERT lamp is turned OFF on the CH/MH-53 aircraft.***

Fixed Minimum Recovery Altitude (FMRA)

PMA-209

GPWS

[Impending CFIT]

This warning is issued when the GPWC computes that the Predicted Recovery Altitude (PRA) for the aircraft is equal to or less than Minimum Recovery Altitude (MRA) over three iterations. Each iteration takes one tenth of a second. The MRA is set at 0 feet Above Ground Level (AGL). This warning is enabled at all times the aircraft is in the flight state and is more than 40 feet AGL after take off or just before landing.

Aural warning ***"WHOOP WHOOP PULL UP PULL UP"***
Warning issued once.

Visual warning ***GPWS ALERT lamp on the Caution Advisory Panel illuminates***
stays lit for the CH/MH-53 series aircraft. There is no indication
for the CH-46E aircraft .

Re-arm Condition ***Aircraft has a positive rate of climb and climbs through 50 feet***
AGL. The ALERT lamp is turned OFF.

Glideslope

GPWS

This alert (CH/MH-53Es only) is issued whenever the aircraft receives a valid glideslope input, the altitude is less than 1000 feet, the aircraft is within three dots horizontally of the localizer front course, and descends below the glideslope limits set in the GPWC. The glides lope alert is issued at 1000-150 feet when the aircraft is 1.3 dots below the glideslope; at 100 feet when the aircraft is 2 dots below the glideslope; and at 50 feet when the aircraft is 2.7 dots below the glideslope as read on the ILS indicator.

Aural alert ***"BELOW GLIDESLOPE BELOW GLIDESLOPE"***
Alert repeated every 3 seconds.

Visual alert ***GPWS ALERT lamp on the Caution Advisory Panel***
illuminates and stays lit.

Re-arm Condition ***Re-intercept the glide slope. The ALERT lamp turns off.***

Note: The MH-53E has a back course selectable input installed that can be used to inhibit potential back course "Below Glideslope" warnings when flying back course approaches.

Excessive Bank Angle

GPWS

This alert is issued whenever the aircraft's bank angle exceeds 50° for CH-46E aircraft or 60° for the CH/MH-53 series aircraft.

Aural alert ***"BANK ANGLE BANK ANGLE"***
Alert issued once.

Visual alert ***GPWS ALERT lamp on the Caution Advisory Panel***
illuminates and stays lit for the CH/MH-53 series aircraft.
There is no indication for the CH-46E aircraft .

Re-arm Condition ***Aircraft bank angle decreases below 50° for the CH-46E***
aircraft or 60° for the CH/MH-53 series aircraft or less.
The ALERT lamp is turned OFF.

Landing Gear Up

GPWS

This alert (Applicable only to CH/MH-53 series aircraft) is issued whenever the GPWS landing gear up criteria is violated. This alert is enabled when the aircraft is in the air and either of the following occurs:

1. Radar altimeter signal is valid, aircraft less than 150 feet AGL, Indicated Air Speed (IAS) is less than 60 knots, and the landing gear is up.

2. Radar altimeter signal in invalid, IAS is less than 60 knots, and the landing gear is up.

Aural alert "GEAR GEAR"

Alert is repeated every 3 seconds.

Visual alert GPWS ALERT lamp on the Caution Advisory Panel illuminates and stays lit.

Re-arm Condition Gear is lowered, or radar altitude => 150 feet AGL, or IAS => 60 knots, or the Landing Gear Reset switch is pressed. The ALERT lamp is turned OFF.

Note: Alert can be deactivated by using the pre-existing landing gear warning system inhibit switch in the gear handle. GPWS then reactivates the alert when IAS => 60 knots or the aircraft descends below 15 feet AGL.

Tail Strike

GPWS

The tail strike alert is issued whenever a potential tail strike is detected. This warning is enabled when the aircraft violates the pitch angle versus altitude criteria which closely follows the CH-53E NATOPS. Applicable only to the CH/MH-53 aircraft.

Aural alert "TAIL"

Alert issued once.

Visual alert GPWS ALERT lamp on the Caution Advisory Panel illuminates and stays lit.

Re-arm Condition Initial warning conditions no longer violated. The ALERT lamp is turned OFF.

GPWS

Built in Test (BIT)

GPWS Input Fault History

The GPWC records in non-volatile memory all input faults each time the input fault occurs during a flight. Maintenance personnel can access the aural input fault BIT history of the last two power on cycles using the Commanded Built In Test (C-BIT) push button on the GPWC Mounting Base.

Aural fault history is presented over the ICS in the following order upon executing C-BIT:

1. Current faults annunciated.
2. “Tone” last power cycle faults annunciated.
3. “Tone”, “Tone” second power cycle faults annunciated.
4. “Tone”, “Tone”, “Tone” no fault history in last two power on cycles.

NOTE: C-BIT will cycle history each time it is depressed.

Introduction to BIT

BIT is implemented in the GPWC to accomplish system failure detection. BIT is capable of fault isolation to the WRA level. All major system components and inputs are evaluated by BIT. BIT evaluates the condition of the GPWC and external avionics sensors interfaced to the GPWC.

Three levels of BIT provided by the GPWC:

1. Initialization BIT (I-BIT)
2. Periodic BIT (P-BIT)
3. Commanded BIT (C-BIT).

Initialization BIT (I-BIT)

The GPWC will perform I-BIT upon application of primary power, to verify the operational status of the system. The I-BIT takes up to 20 seconds.

After I-BIT is completed, the aural results are as follows:

1. **“Whoop Whoop Pull Up Pull Up”, “Bank Angle Bank Angle”,** then

   “GPWS READY” or **“GPWS FAULT”**

2. Illumination of the INOP lamp on the Caution Advisory Panel indicates failure for the CH/MH-53 series aircraft.

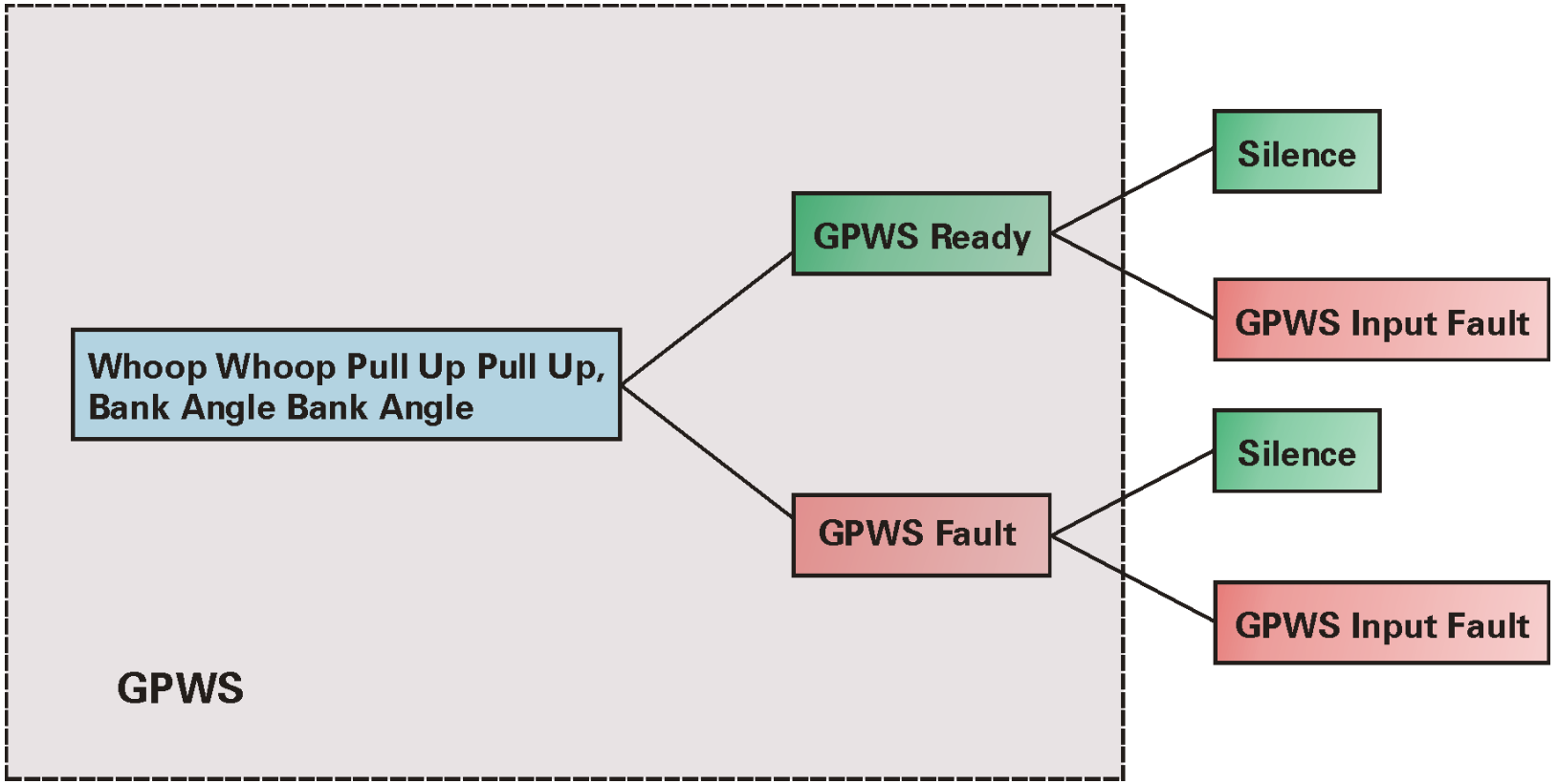
3. “Go” or “No Go” status is displayed on the CDNU for the CH-46E aircraft.

Initialization BIT (I-BIT) (Cont'd)

Note that "GPWS Fault" pertains to the GPWC only. If "GPWS Fault" is heard, the problem lies with the GPWC.

If "GPWS Input Fault #" is heard, the problem may be with the system feeding that input to the GPWC, but it also may be with the wiring and connections between the system feeding inputs to the GPWC and the GPWC itself. When "GPWS Input Fault #" is heard, this means only that the GPWC interface is not receiving the signal. Before removing and replacing any non-GPWS WRA, ensure that the problem is not in the connections and wiring first.

Initialization BIT (I-BIT) (Cont'd)



External to GPWC

Periodic BIT (P-BIT)

After I-BIT has been completed and the system is operational, the GPWC automatically performs P-BIT to detect failures. P-BIT is performed at least once every 3 minutes. P-BIT diagnostics operate during pre-flight, in-flight, and post-flight operations on a non-interference basis with normal GPWS functions.

P-BIT performs the following:

1. Detects functional failures.
2. Isolates the failures to the failed WRA.
3. Provides an INOP indication to the crew for a failed function.
4. Upon detection of a failure, determines GPWS operational status.
5. All detected failures are stored.
6. P-BIT stores and records detectable and isolatable O-level repairable/replaceable assembly failures on the system for maintenance personnel information.

Commanded BIT (C-BIT)

The GPWC will perform C-BIT when:

1. The “Push- To-Test” switch located on the mounting base is pressed
2. The system test page for the GPWS is accessed on the CDNU for the CH-46E aircraft only

C-BIT is the major troubleshooting tool of maintenance personnel.

The “Weight-On-Wheels” discrete input is used to prevent a C-BIT from being executed in the air, since C-BIT will interrupt normal system operation.

BIT Status Reporting

The GPWC reports the results of BIT the following ways:

1. Voice messages over the ICS

2. INOP lamp on the Caution Advisory Panel for the CH/MH-53 series aircraft

3. “Go” or “No Go” status with fault details on the CDNU for the CH-46E aircraft

Successful BIT

GPWS

For I-BIT successful completion is recognized by:

1. **“Whoop Whoop Pull Up Pull Up”**, **“Bank Angle Bank Angle”**, and **“G” “P” “W” “S” “Ready”** are annunciated.
2. “Go” status will appear on the CDNU for the CH-46E aircraft.

For C-BIT successful completion is recognized by:

1. The annunciation of **“G” “P” “W” “S” “Ready”.**
2. “Go” status will appear on the CDNU for the CH-46E aircraft.

P-BIT does not provide an aural or visual confirmation of successful completion.

Failed BIT

On the ground IBIT:

1. “Whoop Whoop Pull Up Pull Up”, “Bank Angle Bank Angle”, and **“G” “P” “W” “S” “Fault”** or **“G” “P” “W” “S” “Input Fault #”** are annunciated.
2. INOP lamp on the Caution Advisory Panel will light for the CH/MH-53 series aircraft
3. “No Go” status on the CDNU for the CH-46E aircraft .

On the ground C-BIT:

1. **“G” “P” “W” “S” “Fault”** or **“G” “P” “W” “S” “Input Fault #”** are annunciated.
2. INOP lamp on the Caution Advisory Panel will light for the CH/MH-53 series aircraft
3. “No Go” status on the CDNU for the CH-46E aircraft .

If GPWS Fails BIT

In the air:

1. No voice messages are annunciated
2. Continuously lit INOP lamp for the CH/MH-53 series aircraft
3. Continuous “No Go” status on the CDNU for the CH-46E aircraft

If the fault is subsequently corrected:

1. INOP light extinguishes for the CH/MH-53 series aircraft
2. Status changes to “Go” on the CDNU for the CH-46E aircraft

BIT Advisories

BIT advisories are reported differently on the ground than in the air. While on ground, both aural and visual indications may be reported. In flight, only visual indications are possible.

BIT reports available:

1. Application of power to the GPWS Processor on the ground and I-BIT completes satisfactorily, or a previously detected BIT fault is corrected:

Aural warning "Whoop Whoop, Pull Up, Pull Up, Bank Angle, Bank Angle, GPWS READY"

Visual warning GPWS INOP lamp on the Caution Advisory Panel is OFF for the CH/MH-53 aircraft /"Go" status on the CDNU for the CH-46E aircraft.

BIT Advisories (Cont'd)

GPWS

BIT reports available (cont'd):_

2. Application of power to the GPWS Processor in flight (such as a power interruption) and I-BIT was completed satisfactorily, or a previously detected BIT fault is corrected:

Aural warning	***None***
Visual warning	***GPWS INOP lamp on the Caution Advisory Panel is OFF for the CH/MH-53 aircraft /"Go" status on the CDNU for the CH-46E aircraft.***

BIT Advisories (Cont'd)

GPWS

BIT reports available (cont'd):_

3. A BIT fault is detected while the aircraft is on the ground:

Aural warning ***"GPWS FAULT" or "GPWS INPUT FAULT #"***

Visual warning ***GPWS INOP lamp on the Caution Advisory Panel is ON for the CH/MH-53 aircraft or "No Go" status on the CDNU for the CH-46E aircraft.***

BIT Advisories (Cont'd)

GPWS

BIT reports available (cont'd):_

4. A BIT fault is detected while the aircraft is in the air:

Aural warning ***None***

Visual warning ***GPWS INOP lamp on the Caution Advisory Panel is ON for the CH/MH-53 aircraft or "No Go" status on the CDNU for the CH-46E aircraft.***

GPWS BIT Messages

GPWS

Annunciation Messages	Invalid Sensor Input
GPWS Fault	GPWS Processor
GPWS Input Fault One	Radar Altimeter
GPWS Input Fault Two	Internal Normal Accelerometer
GPWS Input Fault Three	Displacement Gyro
GPWS Input Fault Four	Air Data Computer
GPWS Input Fault Five	Barometric Altitude
GPWS Input Fault Six	Barometric Altitude Rate
GPWS Input Fault Seven	Indicated Airspeed
GPWS Input Fault Eight	Weight-On-Wheels/ Landing Gear Position
GPWS Input Fault Nine	Configuration Pins
GPWS Input Fault One-Zero	Engine Torque

Reference Data

- Airframe Change 501, Part 1 (CH-53D)
- Airframe Change 501, Part 2 (CH-53E)
- Airframe Change 501, Part 3 (MH-53E)
- Airframe Change 479 (CH-46E)
- Cubic Product Function Specification for the AN/AYQ-23(V), SP-0251-01
- Cubic Interface Control Document for CH-53D, ICD-0251-02
- Cubic Interface Control Document for CH-53E, SP-0251-02
- Cubic Interface Control Document for H-53 Simulator, ICD-0251-07
- Cubic Interface Control Document for CH-46E, ICD-0251-03
- MIL-STD-1553/SAE AS15531 Interface Control Document for CH-46E, ICD-0251-04

Limitations

GPWS

Not Forward Looking

Cannot Detect Ultimate Height Of Projections Or Of Rising Terrain

Warnings Cannot Be Silenced to Avoid Garbling of Other Voice Traffic On ICS (Except for Gear Warning In CH-53E/MH-53E/CH-53D)

Nuisance “Below Glideslope” Warnings When Conducting A Backcourse Localizer Approach Due To Undefined Antenna Lobes (Except On MH-53E)